2018

State Management of Human– Wildlife Conflicts

Kurt C. VerCauteren
USDA APHIS Wildlife Services, kurt.c.vercauteren@aphis.usda.gov

Daniel Hirchert
USDA APHIS Wildlife Services, daniel.l.hirchert@aphis.usda.gov

Scott Hygnstrom
University of Nebraska-Lincoln, shygnstrom1@unl.edu

In T. Ryder, editor. State Wildlife Management and Conservation. Johns Hopkins Press, Baltimore, MD. 2018. pp. 161-175.

11

State Management of Human–Wildlife Conflicts

Kurt VerCauteren,
Daniel Hirchert,
and Scott Hygnstrom

Many positive experiences are associated with wildlife, from passively watching animals in our backyards to actively hunting in publicly owned forests. Unfortunately, wildlife can be a double-edged sword. Human–wildlife conflicts are pervasive in society, and nearly all segments—wealthy and in need, urban and rural, east and west—can experience problems with wildlife. Agricultural producers lose an estimated $45 billion each year as a result of crop and livestock damage caused by big game, predators, waterfowl, and other wildlife species (Conover 2002). Row crops, forages, rangeland, fruits, vegetables, ornamentals, turf, and livestock are susceptible to damage by wildlife at various stages of production. Inhabitants of urban/suburban areas endure significant damage and nuisance problems caused by bears, deer, raccoons, squirrels, pigeons, rabbits, skunks, snakes, and others. In addition, over 75,000 people are injured annually or become ill as a result of wildlife-related incidents, at costs well exceeding $10 billion annually (Conover 2002).

Coexistence with wildlife is a balancing act of dealing with their positive and negative impacts. Many state wildlife agencies have taken on the responsibility of reducing these negative impacts for the betterment of society. Wildlife damage management (WDM) is an increasingly important part of the wildlife profession because of expanding human populations and intensified land-use practices. Concurrent with this growing need to reduce human–wildlife conflicts, public attitudes and environmental regulations are restricting use of some traditional control tools, such as toxicants and traps. Agencies and individuals carrying out control programs are being scrutinized more carefully to ensure that their actions are justified, environmentally safe, humane, and in the public interest. Thus, WDM activities must be based on sound economic, scientific, and sociological principles and carried out as positive, necessary components of overall wildlife management programs (VerCauteren et al. 2012a).

Definitions

Wildlife Damage Management

The term "wildlife damage management" can be specifically defined as the process of dealing with free-ranging vertebrate species that (1) cause economic damage to food, fiber, personal property, and natural resources; (2) threaten human health and safety through attacks, collisions, and zoonotic diseases; and (3) create a nuisance that is less than economically significant.

Integrated Wildlife Damage Management

Agencies have adopted an "integrated wildlife (damage) management" approach that incorporates the timely use of a variety of cost-effective, environmentally safe, and socially acceptable methods that reduce human–wildlife conflicts to tolerable levels. For most wildlife problems, no silver bullets exist for resolving issues. To enhance effectiveness and efficiency, proce-

dures should be applied when problem animals are particularly susceptible, before they establish a pattern of conflict, or before populations become overabundant. Seldom will a single technique effectively reduce problems, and multiple techniques tend to work synergistically to enhance effectiveness. Efficiency is critical and benefits must exceed costs if WDM practices are to be sustainable. Care should be taken to use practices that have the least potential impact on the environment and nontarget animals. State wildlife agencies and the US Environmental Protection Agency (EPA) closely monitor and regulate the materials and practices that are used in WDM. The measure of success in WDM should be reduction of damage, threats, or impacts to tolerable levels, rather than the total elimination of damage or a problem population or species.

Overabundance

Wildlife damage often is caused by the offending behavior of individual animals, which can be dealt with by removing them or modifying their habitat. Equally important are the density-dependent impacts that are caused when populations of wildlife become overabundant and their numbers exceed biological and cultural (social) carrying capacity. Overabundance is caused by high fecundity and survival of a species over time, leading to high rates of population growth (McShea et al. 1997) and associated human–wildlife conflicts in areas where high population levels compete with other land uses or human activities.

Biological Carrying Capacity

Biological carrying capacity is the number of animals in a population that an environment can sustain without long-term detrimental impacts to that environment (Ehrlich and Holdren 1971). For example, when white-tailed deer become overabundant, a browse line appears on shrubs, trees, and ornamentals. The plants have few live branches below 6 feet, undergrowth is dramatically limited, and plant diversity is reduced owing to overbrowsing. Eventually, the population of deer will decline as a result of starvation, disease, and competition. Long-term environmental damage will occur long before the deer population declines.

Cultural (Social) Carrying Capacity

Cultural carrying capacity is defined as the number of animals in a population that people are willing to tolerate based on a balance of environmental and social benefits and costs (Seidl and Tisdell 1999). For example, the public's tolerance of deer–vehicle collisions

Overabundance of wildlife, like these wild turkeys, can result in conflict within urban settings. *Photo courtesy of the USDA APHIS Wildlife Services.*

and agricultural damage is influenced by the benefits they experience from viewing and hunting deer.

Responsibility

State wildlife agencies have been charged with the responsibility of managing our publicly owned wildlife resources through the public trust doctrine (PTD; Batcheller et al. 2010). The PTD entrusts state wildlife agencies to manage wildlife resources for the benefit of the public, who owns these resources. Throughout the twentieth century, the primary focus of state wildlife agencies was on protecting wildlife, managing habitats and consumptive uses, and bringing some species back from the brink of extinction. It also stands to reason that these public agencies should be responsible for managing damage caused by wildlife.

Responsibility can be seen in two contradicting forms: (1) individuals can be responsible for protecting personal property from wildlife damage, and (2) society can be responsible for protecting wildlife by restricting what individuals can do to protect personal property. For example, a farmer cannot simply shoot deer to protect crops. State wildlife agencies carefully control the take of deer with hunting seasons, permit quotas, bag limits, and several other restrictions. Therefore, because society limits what farmers can do to protect their livelihood, it stands to reason that society and its empowered state wildlife agencies have the responsibility to assist farmers in reducing damage caused by wildlife.

State wildlife agencies must also protect the environment or endangered species from damage caused by overabundant wildlife. For example, deer overbrowsing in woodlands may eliminate sensitive or endangered plants. Excessive predation may threaten endangered colonial waterbird nesting sites. Wildlife agencies have a responsibility to maintain the long-term viability of rare or endangered species and enhance biodiversity.

History

Once called animal damage control and vertebrate pest control, experts in the field explored new terminology that would be more accurate, descriptive, and publically acceptable, leading to the contemporary terms of WDM (Cook 1991), human–wildlife conflicts, and ultimately human–wildlife coexistence. The first documented governmental act of WDM in the United States was conducted in 1683, when William Penn established a bounty on wolves to protect livestock owned by colonists (Lovich 1987). In 1886, the US Department of Agriculture (USDA) created the Division of Economic Ornithology and Mammalogy (renamed Division of Biological Survey in 1905) to address agricultural damage caused by mammals and birds. Their mission was codified in 1931 with the passage of the Animal Damage Control Act, which empowered the USDA to investigate, demonstrate, and control mammalian predators and rodent and bird pests (USDA 2015). In 1939, responsibilities were transferred to the Department of the Interior, US Fish and Wildlife Service's (USFWS) new Branch of Predator and Rodent Control (renamed Division of Wildlife Services in 1965). Throughout this period, most WDM was conducted by the lethal means of trapping, shooting, and poisoning. In the federal government, these activities were counter to the changing mission of the USFWS, and the Division of Wildlife Services soon fell out of favor with the agency. In 1985, responsibilities for WDM were shifted back to the USDA in the division that is today known as Wildlife Services (WS). The mission of WS is to provide federal leadership and expertise to resolve wildlife conflicts to allow people and wildlife to coexist.

Over time, some state agencies created programs that addressed wildlife damage, wildlife diseases, and nuisance wildlife. For example, from 1931 to 1980, the Wisconsin Department of Natural Resources (WDNR) administered a compensation program to pay landowners for damage to commercial crops and trees caused by deer and bear (Hygnstrom and Craven 1985). Sandhill cranes and waterfowl were later included in the program. In 1983 the program was tweaked and legislation created Wisconsin's Wildlife Damage Abatement and Claims Program (WDACP). The focus of this program was on damage compensation, with damage claims paid on a prorated basis. In 2013, 1,124 landowners voluntarily enrolled in the WDACP and requested damage abatement assistance on 255,702 acres of land, and the WDNR paid $1,394,577 on 325 wildlife damage claims (Koele et al. 2013). Eighty-three percent of the assessed

losses were attributed to white-tailed deer. Such programs are not common, as currently only 13 state wildlife agencies pay compensation for wildlife damage.

Today, the field of WDM is recognized as an integral part of contemporary wildlife management. Evidence of this is seen in The Wildlife Society, an organization of wildlife professionals, which charters a Wildlife Damage Management Working Group with over 200 members. The Working Group supports a biennial Wildlife Damage Management Conference and associated proceedings that are national in scope. In addition, the Vertebrate Pest Council in California has hosted a biennial Vertebrate Pest Conference and associated proceedings since 1963 that are national/international in scope. During the past decade, at least 18 states across the nation have utilized University Extension Specialists with a focus in WDM. Products of their efforts and state and federal wildlife agency personnel include the Internet Center for Wildlife Damage Management, which is a clearinghouse of online information that at last count entertains 1.5 million visitors from all 50 states and 245 countries (Hygnstrom et al. 2015). A two-volume, 863-page book entitled *Prevention and Control of Wildlife Damage* (Hygnstrom et al. 1994) includes information on problem species, from alligators to polar bears, in North America. Two textbooks on the topic of WDM have been produced, *Resolving Human–Wildlife Conflicts: The Science of Wildlife Damage Management* (Conover 2002) and *Wildlife Damage Management: Prevention, Problem Solving, and Conflict Resolution* (Reidinger and Miller 2013), and are used in university courses across the nation.

The Role of States in Wildlife Damage Management

All states within the United States have developed laws and regulations to address various aspects of WDM and conflict management. Programs designed to assist citizens and communities often include technical assistance, investigation, compensation, land-use planning, and implementation of direct WDM practices. As populations of some species increase, or human land uses change, demand for services increases. Increasing WDM functions can burden state wildlife agencies and prevent fulfillment of other mission-related duties.

We conducted a survey of all 50 states and seven US territories in 2015 to determine their levels of involvement in WDM over the past five years. Initially, we examined all state wildlife agency websites and searched for information on wildlife damage, nuisance wildlife, and compensation. Then we contacted coordinators of WDM programs, or personnel most actively involved in WDM assistance. We sought responses for a series of questions, and the number of states answering each question is shown in parentheses.

We found considerable variability in the level of engagement by state wildlife agencies in assisting the public with human–wildlife conflicts. The number of species for which people are eligible for assistance by state ranged from "none" (12) to "all" (2). Most states focused efforts on game species (36), predators (21), furbearers (17), Canada geese (17), mesopredators (12), rodents (12), feral swine (8), bats (8), wild turkeys (6), and invasive species (6). In addition, problem types for which assistance could be obtained from state wildlife agencies varied from "none" (34) to "all" (10), and more specifically, growing crops (12), livestock (11), apiaries (6), stored crops (5), orchards (5), nurseries (4), garden crops (3), personal property (2), fences (2), forage crops (2), and irrigation equipment (1). Technical assistance and information were provided on 44 websites. Several had web pages that focused on "Wildlife Damage," "Living with Wildlife," and "Nuisance Wildlife." Technical assistance included species summary information, fact sheets on a wide range of species (up to 25), links to online resources, annual program reports, depredation regulations, lists of licensed wildlife control operators and trappers, and toll-free help lines.

Hands-on assistance was provided by 12 agencies, and 17 states provided cost-share programs for abatement materials, mostly fences for deer and bear. Thirteen states reported providing compensation for damage caused primarily by deer, elk, bear, wolf, and Canada geese (from $9,000 to $1.9 million per year). Depredation, shooting, or kill permits that allow property owners to react to damage were provided by 35 states, mostly for big game species such as deer (11), elk (3), bear (3), moose (2), pronghorn (2), and feral swine (2), but also including coyotes, mesopredators, squirrels, Canada geese, wild turkey, and wolves. Several

states indicated that WDM is part of the responsibilities of all their wildlife field staff. Eight states reported employing 1–27 full-time staff dedicated to resolving human–wildlife conflicts. Twenty states reported managing annual budgets to support WDM programs, with funding levels ranging from $40,000 to $2.9 million per year. Annual budgets were supported by a variety of sources, including state game cash funds, hunter license fees, surcharges on deer and elk hunting licenses, sale of antlerless deer tags, state general revenue funds, Pittman–Robertson funds, grants, contracts, organizational funds, and interest in endowment funds.

Thirty-two state wildlife agencies provided oversight of the private wildlife control industry, in which 22 states required training. Nearly all state wildlife agencies restricted which species could be handled and managed by private wildlife control operators. State wildlife agencies collaborated with a wide range of agencies, organizations, industries, and individuals in implementing their WDM programs. Most notable were WS (21), the USFWS (10), and University Extension (7). Effectiveness of these collaborations was rated as high (9), medium (2), and low (0).

Federal Role in Assisting States

Wildlife do not abide by political boundaries, and thus cooperation is required for successful prevention and resolution of human–wildlife conflicts. As a result of shared authority, complexity, high costs, availability of expertise, or shared vision, states routinely work with federal, county, and nongovernmental land management agencies and organizations, as well as interest groups and individuals, to achieve goals.

Most states share WDM responsibility with federal WS for some species. Most WS programs are based on a state's need for assistance and expertise and work directly with state agriculture or natural resources agencies. In some cases, federal resources can augment state cost-share programs, allowing for greater service to those seeking relief. The division of duties typically is detailed in cooperative service agreements between agencies. Additional agreements exist among WS and county, township, and municipal governments; industry; and individuals for the provision of WDM services.

Legal Issues

Local, state, and federal laws and regulations are designed to manage wildlife, reduce human–wildlife conflict, and protect the public. We address several federal laws below that are applied across all states and territories. State and local regulations frequently are more restrictive than federal regulations and are too numerous to be addressed here. Wildlife control operators, pesticide applicators, hunters, trappers, wildlife rehabilitators, and those who manage wildlife populations must be aware that federal, state, and local laws and regulations all apply.

The Endangered Species Act (ESA) was passed in 1973 to protect imperiled plant and animal species. The ESA requires that an endangered or threatened species not be injured or harassed by wildlife control activities. Endangered and threatened species cannot be killed, harmed, or collected except under carefully described circumstances and only with appropriate federal and state permits. The presence of endangered or threatened species can affect how WDM activities occur by restricting use of traps, toxicants, and other control methods.

The Migratory Bird Treaty Act (MBTA) of 1918 protects all migratory birds in North America. Migratory birds and their nests and eggs cannot be taken, possessed, or transported without a federal permit. This does not include pigeons, house sparrows, or European starlings, which are non-native invasive species. Before attempting to control a migratory bird (e.g., woodpeckers, raptors, and waterfowl), landowners must obtain a 50 CFR Bird Depredation Permit. The permit allows the taking of migratory birds that destroy public or private property, threaten public health or welfare, and are a nuisance. The permit states the conditions under which the birds may be controlled and the methods that may be used. Permit holders may control migratory birds that are causing or are about to cause serious damage to crops, nursery stocks, or fish in hatcheries. An exception in the MBTA (50 CFR 21.43) is that "a federal permit shall not be required to control red-winged and Brewer's blackbirds; cowbirds; all grackles, crows, and magpies; when found committing or about to commit depredations upon ornamental or shade trees, agricultural crops, livestock, or wildlife, or

when concentrated in such numbers and manner as to constitute a health hazard or other nuisance." Some states also have obtained a federal General Depredation Order for controlling Canada geese, gulls, and cormorants that are causing conflicts, inflicting property damage, or threatening endangered wildlife. A recent exception to the MBTA allows wildlife control operators to rescue migratory birds trapped inside buildings, provided that the birds are released unharmed and onsite.

In addition to the MBTA, the Bald and Golden Eagle Protection Act (BGEPA) of 1940 (amended in 1962 to include golden eagles) provides further protection for these two species, regardless of status under the ESA. The BGEPA prohibits "the take, possession, sale, purchase, barter, offer to sell, purchase or barter, transport, export or import, of any bald or golden eagle, alive or dead, including any part, nest or egg, unless allowed by permit" (16 U.S.C. 668 (a); 50CFR 22). Therefore, if WDM is needed for eagles that are jeopardizing human health and safety, or depredating livestock, additional permitting is required for the WDM entity.

The Federal Insecticide, Fungicide and Rodenticide Act (FIFRA), originally passed in 1947, established federal control of the distribution, sale, and use of pesticides. It has been amended several times and regulates the availability and use of all pesticides, including repellents and toxicants, including those used in WDM. It also mandates that the EPA provide oversight of research, registration, certification, sale, and use of pesticides to protect human health and the environment.

The National Environmental Policy Act (NEPA), enacted in 1970, promotes enhancement of the environment. The most significant outcome of the NEPA was the development of a process by which all executive federal agencies prepare environmental assessments (EAs) and environmental impact statements (EISs) that document the potential environmental effects of proposed projects in which a federal agency provides any portion of financing for the project, including WDM projects. The act does not apply to state actions where there is a complete absence of federal influence or funding.

Wildlife species that are not regulated by the federal government fall under state jurisdiction. In most cases where federal laws do apply, state laws and regulations add restrictions to those federal laws. They cannot be less restrictive. Under state law some problem species are unprotected and have no restrictions on their take. For example, many western states allow the unlimited take of coyotes and pocket gophers year-round. In eastern states, however, coyotes often are listed as a game animal with closed seasons and limited methods of harvest. States typically classify wildlife in the following ways: (1) "game species," which may be legally hunted; (2) "furbearer species," which are captured for fur, usually through trapping; (3) "nongame species," which are protected and for which no open seasons are available for their harvest; and (4) "unprotected species," which typically are non-native invasive species, or species that are very abundant. State and local ordinances may further restrict and define control activities. Local regulations may limit the techniques that can be used in controlling birds.

Linking Research, Practice, and Theory in Managing Human–Wildlife Conflicts

Conflict between humans and wildlife is increasing across American landscapes owing to urban and suburban expansion into new areas, changes in land-use practices, changes in resource extraction and production regimes, and shifts in wildlife management policy. To address the increasing conflicts, wildlife professionals build on basic ecological knowledge of population dynamics, animal behaviors, and landscape ecology to practice a form of applied ecology that exploits what we know about species to avert conflict in manners that align with long-held American beliefs, including the "greatest good for the greatest number in the long run" and Leopold's "land ethic." We draw on the overarching paradigm of the North American Model of Wildlife Conservation (NAMWC), which is covered elsewhere in this volume, when discussing WDM. All of the NAMWC components apply well to WDM, with the possible exception of "Non-Frivolous Use," which states that one can "legally kill certain wildlife for legitimate purposes" (Organ et al. 2012). This phrase is problematic because it assumes that the legitimacy of killing is not on a sliding scale based on individual circum-

stances, desires, and ethics. Regardless, the NAMWC is generally applicable to WDM and is being continually refined.

WDM programs can be thought of as having four parts: (1) problem definition, (2) ecology of the problem species, (3) management methods application, and (4) evaluation of management effort. Problem definition refers to determining the species and numbers of animals causing the problem, the amount of loss or nature of the conflict, the human role in the conflict, and other biological and social factors related to the problem. Ecology of the problem species refers to understanding the life history of the species, especially in relation to the conflict. Management methods application refers to taking the information gained from parts 1 and 2 to develop an appropriate management action to reduce or alleviate the conflict. Evaluation of management effort permits an assessment of the reduction in damage in relation to costs and impact of the management effort on target and nontarget populations. Emphasis often is placed on an integrated WDM approach (VerCauteren et al. 2012a).

Tools Used by State Wildlife Agencies to Address Human–Wildlife Conflicts

The specific methods used in integrated WDM often are categorized as lethal and nonlethal.

Lethal Strategies

Offending individual animals, such as gulls at airports, must sometimes be removed to protect human health, safety, and economic resources. Also, when populations of some species, such as white-tailed deer, become overabundant, damage becomes density dependent, and landowners turn to state agencies for relief. In general, three forms of lethal control are used to manage wildlife: shooting, trapping, and toxicants. As free-ranging populations are dynamic, lethal control often must be repeated to be effective. Relative to game species, this cycle of continually growing and harvesting animals at levels acceptable to various publics is a primary goal of state wildlife management agencies.

SHOOTING

State agencies have used regulated recreational hunting as their primary tool for managing game species for decades. In certain situations hunting is used to keep populations of some species from becoming too abundant and causing too much damage to agricultural and other resources. With most game species, agencies study and evaluate populations each year and determine what, if any, changes should be made to harvest levels in subsequent years. Besides being the most practical management tool for many species, hunting also can have social, economic, and ecological benefits. Especially in rural areas across the country, hunting provides many benefits to landowners, hunters, communities, and local economies.

Although regulated hunting often is the most practical and effective tool for managing populations, many situations occur in which it cannot be implemented or would not be effective in curtailing human–wildlife conflicts. An example is when a disease that is transmissible among deer and livestock is detected in a local population of deer. Immediate response is needed, and agency staff or other professionals may be called upon to perform culling to quickly and selectively decrease the population, with the intent of quickly reducing the potential for disease transmission. Similarly, disease or damage depredation permits may be issued to landowners to address local problems quickly. Strategies like this can be very effective because they target the specific population of individuals that are causing damage. Depredation permits differ from recreational hunting permits in that they allow landowners to cull animals that are damaging resources outside of hunting seasons and to use additional tools (lights at night, bait, etc.). In other instances professional shooters can be more effective, such as in culling feral swine or coyotes from aircraft and employing professional sharpshooters to cull deer in urban and suburban settings.

TRAPPING

Recreational trapping and cable restraints are tools used by agencies to manage furbearers in most states. Recreational trappers are an inefficient management tool for reducing damage when fur prices are low, however, because interest in recreational trapping often is

driven by market value of furs. In these cases, agencies such as WS may trap nuisance furbearers. Examples of species and types of damage relative to furbearers include beavers building dams and flooding agricultural fields and roads, raccoons damaging sweet corn and killing poultry, and coyotes killing lambs. Lessons learned by generations of trappers and contemporary trap designs have led to significant advances relative to humaneness and species specificity of trapping and cable restraints. Commonly used tools for furbearers and nuisance species include cage traps, foothold traps, body-gripping traps, and foot-encapsulating traps. All but body-gripping traps can be used for nonlethal purposes as well, but if the intent is to euthanize the captured animal, humane methods such as a properly placed gunshot or asphyxiation by carbon dioxide must be employed when using nonlethal traps.

State agencies sometimes use trapping to manage common or invasive species of birds that are impacting other species of conservation concern. For example, populations of endangered Kirtland's warbler are being depressed in large part because common brown-headed cowbirds lay their eggs in warbler nests and warblers then raise the cowbird chicks instead of their own. Large cage traps are used to capture cowbirds in warbler habitat. The cowbirds are then euthanized humanely by cervical dislocation or asphyxiation.

State wildlife agencies also manage and regulate trapping done by private wildlife control operators or agents. As noted earlier, 22 states now require training for industry professionals who handle problem wildlife. A standardized, online curriculum has been developed, which can be modified for use in any state or province as a basic training program (Curtis et al. 2015). There is a trend toward increasing oversight and regulation of this industry by state wildlife agencies.

TOXICANTS

Toxicants are chemical compounds registered by the EPA that kill target animals through various physiological modes of action, such as coagulation response inhibition, disruption of metabolic processes, and inhibition of nerve impulses. Great care must be exercised in their use to minimize potential risks to humans, pets, livestock, and nontarget wildlife. Restricted use pesticides can only be applied by individuals certified by the EPA, which in WDM typically includes WS personnel and certified pesticide applicators. Many firms that handle residential or commercial wildlife control hire pesticide applicators. While an important tool for rodent and bird control, toxicants seldom are used by state wildlife agencies. However, state agencies, often departments of either agriculture or wildlife, regulate use of toxicants for wildlife control in collaboration with the federal EPA.

In all cases, be it recreational hunting to manage populations on a large scale, application of a toxicant to control an invasive species, or selective trapping to remove a problem individual, lethal methods must be implemented responsibly and as part of a science-based strategy to achieve management and conservation goals. Wildlife researchers continually endeavor to develop strategies that are tailored to the target species, context of the conflict, and economics of the situation, while minimizing any negative impacts.

Nonlethal Strategies

Whenever possible and especially in small-scale local instances, nonlethal strategies are implemented by WDM personnel. They often suggest strategies and even provide labor and materials to help landowners address conflicts. Conover (2002) pointed out that nonlethal methods may result in the deaths of displaced, relocated, and excluded animals. For example, overpopulated animals that are fenced from a resource may suffer if alternative food sources are not available. Similarly, animals that are translocated from areas where they are causing damage to another area may not survive for a variety of reasons, including an inability to assimilate with individuals of the same species already present in the area and having no knowledge of their new landscape, its resources, and its dangers.

In general, nonlethal management strategies can be categorized as either physical or psychological strategies, or a combination of the two. These strategies usually include various forms of exclusion, habitat modification, frightening devices, repellents, reproductive control, and translocation. It must be realized that seldom are these options perfect fixes. Some have better utility than others, and the best tools for one situation may not perform as well in another.

When large animals become accustomed to human foods, dumpsters and other sources must often be fenced in the urban–wildland interface. *Photo courtesy of the USDA APHIS Wildlife Services.*

EXCLUSION

Exclusionary fencing is the most common method for physically separating wildlife from a resource they could damage. A wide variety of fence options are available, and the type used will depend on the level of protection desired, seasonality of the resource being protected, physical ability of the target species, motivation to breach, behavioral characteristics, costs associated with construction and maintenance, longevity of the building materials, and possible negative effects (VerCauteren et al. 2006). For example, a woven-wire fence is expensive upfront but could last 30 years and be virtually 100 percent effective, and thus it may be an excellent investment to keep deer from damaging high-dollar fruit trees. For an annual crop of lesser value, such as corn, a relatively inexpensive and easy-to-erect electric polytape fence may reduce damage even though it is not 100 percent effective in keeping deer out. Thus, while fences can prevent or eliminate agricultural damage, the costs associated with installation, materials, and maintenance can outweigh the economic benefits based on crop values. Fences often are used to exclude ungulates such as deer, elk, and feral swine from high-value crops and predators such as coyotes from small livestock pastures. In addition to fences, other exclusionary protection techniques include bird netting and lines, rodent-proof construction, wire mesh, cylinders, wraps, and bud caps.

HABITAT MODIFICATION

Habitat sometimes can be altered when exclusion is not an option owing to the nature of the resource, prohibitive costs, or environmental concerns. Habitat modification includes altering the biotic and abiotic components of the habitat or changing the management and maintenance of the resource in a manner that alters the carrying capacity for the target species or lessens the desirability of location (Reidinger and Miller 2013). Alteration of habitat can be done from landscape scale down to simply altering a stand of trees in a backyard to prevent birds from roosting. The landscape surrounding an airport can be manipulated to make it less attractive to birds and prey species to minimize bird strikes. For rodents, such as mice and voles, habitat modification can consist simply of mowing or removal of woodpiles, brush, and other habitat. Water levels can be raised and lowered to make habitat conditions inhospitable to beavers and muskrats. In cases where the resource being preyed upon is an agricultural crop, a switch to an unpalatable variety is effective, or altering the planting and harvesting timing can avoid the coinciding of bird migrations with crop vulnerabilities. Habitat modification can be cost prohibitive, owing to the cost of permitting processes, time, and labor; however, strategic modification can alter carrying capacity or desirability of the location for longer periods than other methods (Conover 2002; Reidinger and Miller 2013). Unfortunately, habitat modification often lacks

target specificity, and several other species can be impacted. For example, to resolve a problem of deer causing damage to flower beds in a park, an adjacent woodlot where the deer live could be cut down, burned, and bulldozed, but the procedure would be expensive and impacts to coinhabiting squirrels, raccoons, songbirds, and associated park goers could be undesirable.

FRIGHTENING DEVICES

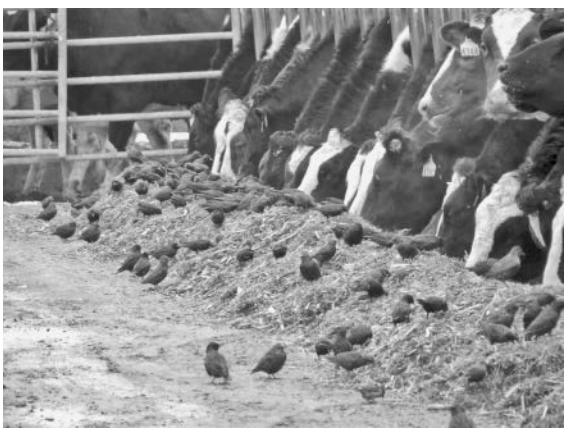
The goal of frightening devices is to influence the behavior of problem animals and move them from areas where they can cause damage. They fall into four categories: visual, auditory, audiovisual, and biological. The effectiveness of most frightening devices diminishes after initial success, as the animals become habituated to the frightening devices with repeated exposure. With the diminishing returns of frightening devices, it is important to consider strategic timing of use, visual or auditory range, and integration of multiple sensory stimuli. Visual frightening devices work by mimicking a predator's shape, sound, or movement to scare the target species or by exposing them to novel visual stimuli. Common visual frightening devices include plastic owls and coyotes, inflatable moving scarecrows, fence ribbons, flags, lasers for dispersing birds, strobe lights, and balloons. Auditory devices emit sounds within the audible range of the target species delivered through systems that are either recordings, such as alarm and distress calls, or controlled explosions, such as propane cannons. Audiovisual devices incorporate both stimuli, such as pyrotechnics, including bird bangers, bird screamers, and cracker shells. Biological frightening devices emulate natural factors that influence the behavior of problem animals. Livestock protection animals such as dogs, llamas, and donkeys are one of the oldest forms of WDM and can be used to reduce predation on livestock caused by canids, felids, and bears. Dogs also have been used to protect livestock from disease by providing a buffer from wildlife species (VerCauteren et al. 2012b) and to protect agricultural crops from damage by deer and other species (VerCauteren et al. 2005). Falcons and falconers have been used at airports to deter birds from using the area.

REPELLENTS

Repellents are chemical compounds registered by the EPA that disperse animals from an area or resource through various olfactory or taste senses associated with pain, displeasure, fear, conditioned aversion, or tactile response. Capsaicin, the chemical compound in chili peppers, induces pain and thus avoidance of treated plants by deer and other herbivores. Predator odors, such as coyote urine, induce fear in many herbivores and can be used as an area repellent. Compounds such as anthraquinone, when applied to turf grass and ingested by geese, induce illness and subsequent avoidance. In addition, polybutenes are sticky, tacky gel-like compounds that when applied to ledges will repel pigeons and squirrels from the area of application. Effectiveness of repellents is highly dependent on the motivation of the animals. If animals are food stressed, repellents likely will not be effective. Effectiveness also is affected by weathering, alternative food sources, and acclimation.

REPRODUCTIVE CONTROL

In some situations, altering the dynamics of the population is the best approach to mitigating the conflict or resource damage. The natality of a population can be changed through reproductive or fertility control, which reduces human–wildlife conflict if damage is density dependent. Reproduction in birds, such as



Overabundant species, like these blackbirds, can cause major conflict with humans and livestock. They are often controlled using repellents. *Photo courtesy of the USDA APHIS Wildlife Services.*

Canada geese, can be reduced during the nesting season by egg removal, but geese often will mitigate this technique by renesting. In addition, eggs can be oiled, addled, or punctured to inhibit hatching, but in most cases over 75 percent of the nests must be treated for several years to have a measurable effect on the population. For long-lived species such as geese and deer, lethal control often has two to three times the effect on population growth as inhibiting reproduction. Generally, fertility control is a long-term and expensive management approach rarely conducted by state and wildlife agency staff.

Strategies to control wildlife fertility include endocrine disruption, immunocontraception, intrauterine devices, surgical procedures, and chemosterilization. Since the late 1950s, research has been conducted on several species, including wild horses, white-tailed deer, prairie dogs, Canada geese, elephants, and bison. Contraceptive methods can only be implemented in specific situations as a result of a combination of needs that may include (1) reversibility, (2) suitable for field delivery, (3) effective with a single dose, (4) no hazard to nontarget species, (5) no harmful side effects, and (6) no effect on the social behavior of the animals (Conover 2002). Currently, few field-deployable single-dose contraceptive methods are available. Gonadotropin releasing hormone and porcine zona pellucida have shown some promise, but as with all chemical contraceptive methods, they have their limitations. While fertility control methods are gaining popularity with the public, they are not yet stand-alone methods for most situations, owing to a lack of applicability with large populations, effectiveness, and field readiness, as well as prohibitive costs. Most fertility control applications are considered experimental by state agency staff, and a research permit may be needed to use such methods. Very few products (e.g., GonaCon and OvoControl) have a current EPA registration for use on wildlife.

RELOCATION AND TRANSLOCATION

Animals that are captured can be relocated, translocated, placed in captivity, or dispatched by humane methods. Relocation is the release of a captured animal within its original home range, typically not far from the capture site. For example, raccoons that

Large carnivores, including black and grizzly bears and mountain lions, are frequently trapped and relocated when they intrude on the urban setting. *Photo courtesy of the USDA APHIS Wildlife Services.*

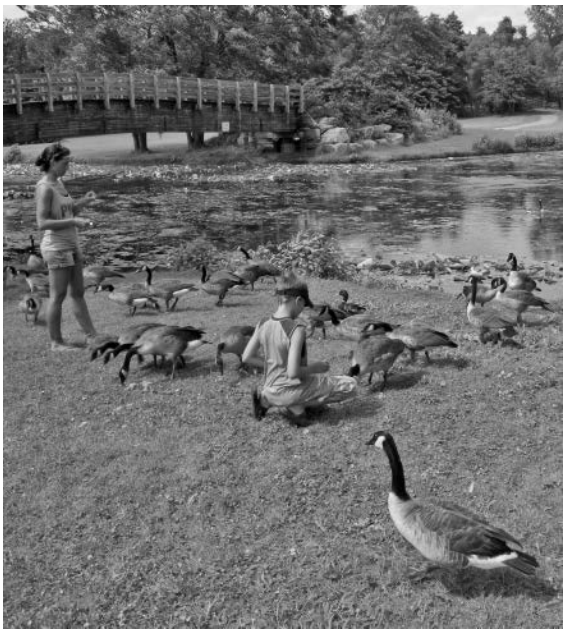
are denning within the chimney of a house can be captured with a cage trap, the chimney can be capped to prevent reentry, and the animals can be released at the base of the chimney. With any luck, raccoons will move away and use a natural cavity for denning, but often they go off in search of another chimney. Translocation is the release of a captured animal outside of its original home range, typically far from the capture site. For example, the same raccoons could be taken 25 miles away to a state wildlife area and released. Homeowners and the public often appreciate the perceived humane treatment of these problem animals. Unfortunately, raccoons and many other species of wildlife have strong homing abilities, and the animals may simply return after a short time and continue to cause problems. Raccoons also are highly territorial, so translocation may cause intraspecific strife with resident raccoons at the release site. Strife may result in injury, death, or disease transmission to the translocated and resident raccoons. In addition, if the translocated raccoons do survive, there are no guarantees that they will not cause problems in the new area. For these reasons, state wildlife agencies often prohibit the translocation of wildlife without specific permits. Three situations may warrant translocation: (1) when the animal is so valuable that euthanasia is not an option, (2) when the population is below carrying capac-

ity at the release site, and (3) when public relations takes precedence over the other two (Conover 2002). Any animal that is a potential threat to human safety should not be translocated and should be removed from the wild.

Human Dimensions of Wildlife Conflict

Human dimensions of wildlife include methods and theory from a variety of disciplines, such as anthropology, sociology, economics, geography, and political science, among others. Human dimensions have become increasingly important, as citizen stakeholders are interested in and exert influence on wildlife policy.

There are three ways in which the American public perceives wildlife: positively affected by wildlife, negatively affected by wildlife, or not affected. The first two choices often sponsor opposing views regarding the need for action, and it may be difficult to reach an agreeable solution that pleases either viewpoint. Those not affected can help develop a course of action involving compromise, as they can look at the situation objectively; however, it may be difficult to attract and hold their interest.



Because overabundant wildlife is often very popular with the public, human dimensions research is often necessary to help address the inevitable conflicts that arise in urban settings. *Photo courtesy of the USDA APHIS Wildlife Services.*

Decision-making for WDM policy is a public process that involves input by managers, stakeholders, and the general public. Within the bounds of local, state, and federal regulations, the decision-maker on privately owned land is often the landowner. For publicly owned lands, a public official typically is authorized to manage the property, but management must meet the legal mandates, and consider the interests and goals, of the public. Stakeholders often are categorized by their position as agricultural producers, rural landowners, urban dwellers, activists, advocates, consumptive resource users (e.g., hunters), and nonconsumptive users (e.g., bird-watchers). Regardless of their categorization, divisions typically align with positively affected, negatively affected, or nonaffected positions on the issue. Information provided by wildlife professionals and community input are crucial for local decision-makers to make informed choices. Several publications are available to assist community leaders and wildlife agency staff when dealing with the human dimensions of overabundant wildlife (Decker et al. 2002, 2004).

Changes in the Future

The field of wildlife management has changed greatly over the past century. Unchanging, however, are the facts that valued resources are damaged by wildlife, conflict between humans and wildlife exists, and wildlife itself is a valued resource. Our landscape is changing, and human-altered environments in some cases may lead to the decimation of habitat and decline of some wildlife populations, while some cases lead to increased diversity of habitats and overabundance of certain species that do well in developed landscapes. Public attitudes toward wildlife are changing, and the changes in public opinion and wildlife management policy never seem to slow or reduce in amplitude. Overabundant native species, invasive alien species, and infectious zoonotic diseases are just a few of the emerging issues that must be faced by wildlife professionals. Resolution of human–wildlife conflict continues to evolve and is a growing area of specialization for future generations of wildlife professionals to make a meaningful impact on wildlife conservation, wildlife

management, and society at large. Highly trained wildlife professionals are needed at the local, state, and federal levels to apply scientific research and practice to the dynamic field of human–wildlife conflict management.

Invasive Species

Human–wildlife conflicts occur with both native and alien invasive species. In an ever more globalized world, there is an increase in exotic/alien species exploiting new ecological niches in the United States (Conover 2002). Federal and state agencies are required to act in the detection and control of invasive species. These species have been introduced either purposefully for hunting and aesthetics or accidentally by escaped animals from agricultural applications, the pet trade, freight, or ballast. Invasive species can displace or eradicate endemic species, damage crops, and cause economic hardship. Among the many established vertebrate invasive species in the United States and its territories are Burmese pythons, brown tree snakes, European starlings, rock pigeons, house sparrows, feral swine, Norway rats, house mice, and nutria. Each of these invasive species provides different challenges in management and control. For example, in the past decades feral swine have been expanding in abundance and distribution, causing an estimated $1.5 billion in annual damages. Feral swine exemplify all major facets of invasive species management and human–wildlife conflict in that they are niche generalists, carry zoonotic diseases, are involved in vehicle–wildlife collisions, damage agricultural crops, kill livestock, damage personal property, alter plant communities, contaminate waterways, and prey on endemic and endangered species.

Overabundant and Urban Deer

Deer populations have responded favorably to management and have adapted well to urban sprawl, and for the past few decades they have been the primary species responsible for several types of damage, including consumption of crops, vehicle accidents, and transmission of diseases to livestock and humans. Over 30 million deer currently occupy the United States (VerCauteren and Hygnstrom 2011). Although they cause millions of dollars of damage each year, as the most popular game species in the country, they are also a huge positive economic resource. The deer-hunting "industry" impacts the country's economy on multiple scales, from the sale of hunting gear and licenses to supporting local businesses and landowners.

State wildlife management agencies work diligently to use regulated, recreational hunting to manage deer populations at levels that provide a balance between positive ecological attributes (hunting and viewing opportunities, intrinsic values) and negative impacts (deer–vehicle collisions, impacts on plant communities, crop damage; VerCauteren et al. 2011). Unfortunately, in many locales it is difficult to reduce deer numbers to goal densities, even with extremely liberal hunting regulations and bag limits. Two of the largest impediments to increasing hunter harvest are that individual hunters only have the willingness and need to harvest so many deer a year and that hunters have difficulty obtaining access to private land that acts as refugia for deer. Across much of white-tailed deer range, the impact of hunting on deer populations is not great enough to reduce deer numbers to meet population goals.

In response to increased deer numbers in urban areas, much has been done in the past 25 years to assist communities with damage caused by deer, and many jurisdictions have implemented plans that include feeding restrictions, making properties less attractive (e.g., reducing cover), barriers, harassment, translocation, lethal removal, and fertility control. The technical guide *Managing White-Tailed Deer in Suburban Environments* (DeNicola et al. 2000) was developed to provide options for persons or communities to consider when experiencing conflicts. Most importantly, state agencies recently have worked cooperatively with municipalities to implement hunting in settings where it has not traditionally been allowed, owing to perceived safety concerns. As a result, urban hunts have become an important tool for managing deer in an increasing number of areas. In both rural and urban landscapes, wildlife professionals are tasked with continuing to develop creative strategies to use hunters and other tools in their efforts to keep deer populations at levels that do not unduly impact their habitats and human

neighbors. Thus, by necessity deer management needs to be dynamic, and managers must work diligently to maintain deer numbers and distribution using a variety of management options.

Nonmigratory (Resident) Canada Geese

Populations of Canada geese declined significantly during the late 1800s and early 1900s primarily as a result of unregulated hunting and egg collecting. It was believed that the giant subspecies of Canada goose (*Branta canadensis maxima*) had actually gone extinct owing to overexploitation. However, a remnant population of giant Canada geese was discovered wintering in Rochester, Minnesota, in 1962. Canada geese typically nest in Canada and migrate significant distances in the fall to winter in moderate climates, but these giant Canada geese avoided migration by staying in an area that provided open water to roost and crops to feed on during the winter. These birds were used to restock areas throughout their former range. This highly successful wildlife restoration project was supported by wildlife agencies, hunters, and bird enthusiasts alike, but they did not anticipate the conflicts that loomed on the horizon. Geese started overwintering in many nontraditional areas of the eastern United States, including parks, golf courses, sewage treatment ponds, and other urban areas that provide open water and food during the winter. These nonmigratory or "resident" Canada geese have benefited from the way humans have altered landscapes, in the form of readily available agricultural fields, turfgrass, and other anthropogenic food sources. Nonmigratory goose populations often thrive because of protections provided by municipal ordinances, lack of predators, or expanses of mowed grass where predators can be observed easily. As geese congregate, they can make green space less attractive for recreational use by the accumulation of fecal deposits. Flocks of resident Canada geese have resulted in beach closings, reduced water quality, erosion, safety concerns at airports, and unsanitary conditions in parks, cemeteries, and yards and on sidewalks near businesses, hospitals, and schools. Adult nesting geese can be protective of their nests and young and become aggressive when an unsuspecting person gets too close to nests. Occasionally, people have been injured during these interactions. Communities that face these concerns often institute a public education effort to persuade people to stop feeding geese. Additional strategies may include the use of herding dogs, repellents, harassment and barrier devices, egg and nest destruction, juvenile translocation, and lethal removal. The technical guide *Managing Canada Geese in Urban Environments* (Smith et al. 1999) was developed to provide options for managers and the public to consider when experiencing conflicts.

LITERATURE CITED

Batcheller, G. R., M. C. Bambery, L. Bies, T. Decker, S. Dyke, D. Guynn, M. McEnroe, M. O'Brien, J. F. Organ, S. J. Riley, and G. Roehm. 2010. The public trust doctrine: Implications for wildlife management and conservation in the United States and Canada. Technical Review 10-01. The Wildlife Society, Bethesda, Maryland, USA.

Conover, M. R. 2002. Resolving human–wildlife conflicts: The science of wildlife damage management. CRC Press, Boca Raton, Florida, USA.

Cook, R. S. 1991. What's in a name? Proceedings of the Great Plains Wildlife Damage Control Workshop 10:165–168.

Curtis, P. D., R. Smith, and S. Hygnstrom. 2015. The National Wildlife Control Training Program: An evolution in wildlife damage management education for industry professionals. Human–Wildlife Interactions 9(2):166–170.

Decker, D. J., T. B. Lauber, and W. F. Siemer. 2002. Human–wildlife conflict management: A practitioner's guide. Northeast Wildlife Damage Management Research and Outreach Cooperative and Human Dimensions Research Unit, Cornell University, Ithaca, New York, USA.

Decker, D. J., D. B. Raik, and W. F. Siemer. 2004. Community-based deer management: A practitioner's guide. Northeast Wildlife Damage Management Research and Outreach Cooperative and Human Dimensions Research Unit, Cornell University, Ithaca, New York, USA.

DeNicola, A. J., K. C. VerCauteren, P. D. Curtis, and S. E. Hygnstrom. 2000. Managing white-tailed deer in suburban environments. Cornell Cooperative Extension, Ithaca, New York, USA. https://ecommons.cornell.edu/handle/1813/65.

Ehrlich, P. R., and J. P. Holdren. 1971. Impact of population growth. Science 171:1212–1217.

Hygnstrom, S. E., and S. R. Craven. 1985. State-funded wildlife damage programs: The Wisconsin experience. Proceedings of the Eastern Wildlife Damage Control Conference 2:234–242.

Hygnstrom, S. E., R. M. Timm, and G. E. Larson. 1994. Prevention and control of wildlife damage. University of Nebraska–Lincoln Extension, Lincoln, Nebraska, USA.

Hygnstrom, S. E., S. M. Vantassel, P. D. Curtis, and R. Smith. 2015. Internet center for wildlife damage management.

Proceedings of the Vertebrate Pest Conference 26:440–442.

Koele, B., D. Hirchert, and N. Balgooyen. 2013. Wildlife damage abatement and claims program. Wisconsin Department of Natural Resources. http://dnr.wi.gov/topic/WildlifeHabitat/documents/reports/damabate.pdf.

Lovich, J. E. 1987. Mountain nightingales: The story of wolves in western Pennsylvania. Mountain Journal 15:3–7.

McShea, W. J., B. H. Underwood, and J. H. Rappole. 1997. The science of overabundance: Deer ecology and population management. Smithsonian Institution Press, Washington, DC, USA.

Organ, J. F., V. Geist, S. P. Mahoney, S. Williams, P. R. Krausman, G. R. Batcheller, T. A. Decker, R. Carmichael, P. Nanjappa, R. Regan, R. A. Medellin, R. Cantu, R. E. McCabe, S. Craven, G. M. Vecellio, and D. J. Decker. 2012. The North American Model of Wildlife Conservation. Technical Review 12-04. The Wildlife Society, Bethesda, Maryland, USA.

Reidinger, R. E., Jr., and J. E. Miller. 2013. Wildlife damage management: Prevention, problem solving, and conflict resolution. Johns Hopkins University Press, Baltimore, Maryland, USA.

Seidl, I., and C. A. Tisdell. 1999. Carrying capacity reconsidered: From Malthus' population theory to cultural carrying capacity. Ecological Economics 31:395–408.

Smith, A. E, S. R. Craven, and P. D. Curtis. 1999. Managing Canada geese in urban environments. Jack Berryman Institute Publication 16, and Cornell University Cooperative Extension, Ithaca, New York, USA. https://ecommons.cornell.edu/handle/1813/66.

USDA (US Department of Agriculture). 2015. Wildlife Services Enabling Legislation. www.aphis.usda.gov/aphis/ourfocus/wildlifedamage/sa_program_overview/ct_legislation.

VerCauteren, K., C. Anderson, T. VanDeelen, D. Drake, W. D. Walter, S. Vantassel, and S. Hygnstrom. 2011. Regulated commercial harvest to manage overabundant white-tailed deer: An idea to consider? Wildlife Society Bulletin 35:185–194.

VerCauteren, K., R. Dolbeer, and E. Gese. 2012a. Identification and management of wildlife damage. Pages 232–269 *in* N. J. Silvy, editor. The wildlife techniques manual, 7th edition. Vol. 1. Johns Hopkins University Press, Baltimore, Maryland, USA.

VerCauteren, K., and S. Hygnstrom. 2011. Managing white-tailed deer: Midwest North America. Pages 501–535 *in* D. G. Hewitt, editor. Biology and management of white-tailed deer. CRC Press, Boca Raton, Florida, USA.

VerCauteren, K., M. Lavelle, T. Gehring, and J. Landry. 2012b. Cow dogs: Use of livestock protection dogs for reducing predation and transmission of pathogens from wildlife to cattle. Applied Animal Behaviour Science 140:128–136.

VerCauteren, K., M. Lavelle, and S. Hygnstrom. 2006. Fences and deer damage management: A review of design and efficacy. Wildlife Society Bulletin 34:191–200.

VerCauteren, K., N. Seward, D. Hirchert, M. Jones, and S. Beckerman. 2005. Dogs for reducing wildlife damage to organic crops: A case study. Proceedings of the Wildlife Damage Management Conference 11:286–293.